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The importance of microalgae for aquaculture industry. Review.

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Abstract
The aquaculture is a fast growing sector and constantly increasing its production. This review was done in order to establish the positive and negative importance of microalgae for the aquaculture due to the growing significance of this sector. The review is divided into four sections: (1) microalgae – a valuable additive in feeding in aquaculture, (2) colloring and biologically active compounds, (3) purification of water, (4) algal toxins.

Keywords: Aquaculture**,** microalgae, toxins, water purification.

1. Introduction
Algae are photosynthetic organisms and they are the ultimate source of both cellular carbon and chemical energy for other organisms. Therefore, they often called primary producers. Generally they categorized as macroalgae (seaweed) and microalgae (unicellular). For the growth of microalgae need light, carbon dioxide and nutrients. The microalgae are cultivated and use for food, for production of useful compounds, as biofilters to remove nutrients and other pollutants from wastewaters, in cosmetic and pharmaceutical industry and in aquaculture purpose. Also microalgae are potentially good sources for biofuel production because of their high oil content and rapid biomass production [1, 2, 3].
The aquaculture is a fast growing sector and constantly increasing its production. The most frequently used microalgae genus in aquaculture are Chlorella, Tetraselmis, Scenedesmus, Pavlova, Phaeodactylum, Chaetoceros, Nannochloropsis, Skeletonema and Thalassiosira. They have rapid growth rates and are stable in culture to possible variation in temperature, light and nutrients as may occur in hatchery systems. Microalgae must have a good nutrient composition, including an absence of toxins that might be transferred up the food chain [4].
The main application of microalgae in aquaculture is connected with their usage for feed purposes. Currently 30 per cent of the world algal production is used for animal feed [5] but the use in aquaculture is mainly for larval fish, molluscs and crustaceans [6]. Waste water from intensive fish farms are enriched with solid particles and dissolved nutrients, mainly in the form of inorganic nitrogen and phosphorus. The use of live microalgae to remove excess dissolved nutrients from aquaculture effluents is an efficient and cost effective waste water treatment method [7]. Microalgae contain numerous bioactive compounds that can be harnessed for commercial use. The pigment responsible for the pink color of salmon and trout is the carotenoid astaxanthin and one of the natural astaxanthin sources is the freshwater green alga *Haematococcus pluvialis* [8].
On the other hand, although a small number of some microalgae release toxins which can cause problems in the freshwater aquaculture of both vertebrates (fish) and invertebrates (shellfish). Severe blooms of even non-toxic algae can spell disaster for cultured hydrobionts, because the blooms deplete the oxygen in the shallow waters of many aquaculture systems.
This review was done in order to establish the positive and negative importance of microalgae for the aquaculture due to the growing significance of this sector.

2. Microalgae – A valuable additive in feeding in aquaculture
Increasing the needs for protein and the high cost of fish meal in the recent years has led to the need to search for new alternatives, as animal and plant sources of protein for the needs of aquaculture. One such accessible and relatively inexpensive food component that could respond successfully the challenge question raised by aquaculture is algae.

Concerning the usage of algae meal (Spirulina sp.) for the replacement of fish meal in the feed for hydrobionts, experiments were conducted with the following species – fish from genera Oreochromis [9], *Siganus canaliculatus* [10], *Oncorhynchus mykiss* [11].

Microalgae are utilized in aquaculture as live feeds for all growth stages of bivalve molluscs (eg. oysters, scallops, clams and mussels), for the juvenile stages of abalone, crustaceans and some fish species, and for zooplankton used in aquaculture food chains [4]. Microalgal species can vary significantly in their nutritional value, and this may also change under different culture conditions [12, 13]. Microalgae have good nutritional properties as monospecies or within a mixed diet which include *C. calcitrans*, *C. muelleri*, *P. lutheri*, *Isochrysis* sp., *T. suecica*, *S. costatum* and *Thalassiosira pseudonana* [13, 14, 15].

Genera of microalgae for larval feeds include Chaetoceros, Thalassiosira, Tetraselmis, Isochrysis, and Nannochloropsis. These organisms are fed directly or indirectly to the cultured larval organism. Indirect means of providing the algae are through artemia, rotifers, and daphnia, which are, in turn, fed to the target larval organisms.

Combination of different algal species provides better balanced nutrition and improves fish growth better than a diet composed of only one algal species [16]. For use in aquaculture a microalgae strain has to ease of culturing, lack of toxicity, high nutritional value with correct cell size and shape and a digestible cell wall to make nutrients available [17].

Protein and vitamin content is a major factor determining the nutritional value of microalgae, also polyunsaturated fatty acid. Different methods are practiced to improve the polyunsaturated fatty acid content in microalgae: manipulation of conditions such as light intensity, nutrient status or temperature allows the modulation of the lipid composition and consequent optimization of their overall yield and productivity [18].

The use of algae as an additive in aquaculture has received a lot of attention due to the positive effect it has on weight gain, increased triglyceride and protein deposition in muscle, improved resistance to disease, decreased nitrogen output into the environment, increased fish digestibility, physiological activity, starvation tolerance and carcass quality [19, 20].

3. Colloring and biologically active compounds

Microalgae such as *Dunaliella salina*, *Haematococcus pluvialis* and *Spirulina* sp. are also used as a source of natural pigments for the culture of prawns, salmonid fish and ornamental fish. *Dunaliella* sp., *Chlorella* sp. and *Spirulina* sp. are three major type that have been used successfully to produced high concentrations of valuable compounds such as lipids, protein and pigments [21, 22, 23]. *Chlorella* sp. and Spirulina sp. are commonly included into feeds for ornamental fish, where colouration and healthy appearance is the main market criterion [24, 25, 26].

Some microalgae are organisms that live in complex habitats with change conditions of salinity, temperature, nutrients, UV-Vis irradiation, therefore, they must adapt rapidly to the new environmental conditions to survive, producing a great variety of secondary (biologically active) metabolites, which cannot be found in other organisms [27]. Rønnestad *et al.* [28] demonstrated that microalgae pigments transferred through to zooplankton may contribute to nutritional value. The pigment lutein is common in "green" microalgae (Tetraselmis spp.) which could be used to improve the nutritional value of Artemia. The lutein could be converted into the vitamin A from halibut larvae when aquatic crustaceans were used as a feed. *Dunaliella salina* is grown for a source of the photosynthetic pigment, beta-carotene. Beta-carotene is used as an orange dye and as a vitamin C supplement.

According Li *et al.* [29] some high-value bioproducts extracted from microalgae are: astaxanthin and leutin produce Haematococcus pluvialis, phycocyanin - Spirulina platensis, polyunsaturated fatty acids – Chlorella sp., Schizochytrium sp., biotin and vitamine E - Euglena gracilis.

The potential of micro-algae as a source of food coloring is limited. The algal-derived food coloring is not photo stable and the color tends to bleach with cooking.

4. Purification of water

Cultivation of microalgae is usually carried out in suitable nutrient media to aggregate a biomass used for food or biofuel production /1, 30/. Except in a nutrient medium for the cultivation of microalgae are used and waste waters from recirculation systems in aquaculture, as they are rich in inorganic and organic substances. Thus establishing that certain types of algae have a potential for integrated use - in water purification from aquaculture and biomass production [31]. Such species are *C. vulgaris*, *N. oculata*, *T. chuii* which show high potential of accumulation in terms of nitrogen and phosphorus compounds contained in the wastewater from aquaculture and could be used for their treatment /32, 33/. The microalgal bioremediation systems in terms of wastewater aquaculture treatment and recycling have received an impetus over the past few years. They are designed to meet specific treatment and wastewater specifications, and may simultaneously solve environmental and sanitary problems along with economic feasibility. The microalgal genera, which have a role like a treatment plant in aquaculture wastewater are Chlorella, Ankistrodesmus, Scenedesmus, Euglena, Chlamydomonas, Oscillatoria, Micractinium and Golenkinia [34], where wastewater-born nutrients are converted into biomass protein. Their morphology as unicellular microorganisms could enable absorbing nutrient more effective compared to terrestrial plant.

In Chile, for example, has some experience to be growing salmon with a specific type of algae that remove phosphorus and nitrogen waste and enrich the water with oxygen, which could also serve as a supplement in the diet of fish [35].

Nowadays are creating a complex aquaculture consisting of microalgae, which could be used for water treatment in fish farming. Wastewater remediation by microalgae is an ecological process without any secondary pollution and the biomass produced is reused [36]. They are considered one of the most efficient, environmentally friendly, relatively low-cost and simple alternative wastewater treatments compared to conventional wastewater treatment techniques [37].

5. Algal toxins

Algal toxins are organic molecules produced by a variety of algae in marine, brackish and fresh waters [38]. They are a problem in aquaculture when they are produced in sufficient quantities, with sufficient potency, to kill cultured organisms, decrease feeding and growth rates [39]. The production of algal toxins is normally associated with algal blooms. Some blue-green algae, particularly Anabaena and Microcystis, produce toxins (cyanotoxins) poisonous to fish. For example neurotoxins are organic molecules that can attack the nervous systems of vertebrates and invertebrates. Neurotoxins are produced by several genera of cyanobacteria including Anabaena, Aphanizomenon, Microcystis, Planktothrix, Raphidiopsis, Arthrospira, Cylindrospermum, Phormidium and Oscillatoria. Neurotoxins produced by Anabaena spp., Oscillatoria spp. and Aphanizomenon flos-aquae blooms have been responsible for animal poisonings around the world [40, 41]. Hepatotoxins are produced by many genera of cyanobacteria and have been implicated in the deaths of fish, birds, wild animals, livestock and humans around the world [40, 41]. Symptoms of poisoning in fish include flared gills because of difficulty breathing and weakness or inability to swim.

Blooms of *Prymnesium parvum* have been responsible for fish kills and significant economic losses in Europe, North America and other continents. The *P. parvum* ichthyotoxin affects gill-breathing aquatic animals such as fish, brachiated tadpoles and mollusks [42]. Relatively recent research has confirmed that Euglena species produce an ichthyotoxin in freshwater aquaculture [43]. Like *E. sanguinea* –this species killed with reddening of gill tissue laboratory-reared channel catfish, tilapia (Oreochromis niloticus) and striped bass.

6. Conclusion

This review shows the practical importance of microalgae for aquaculture, but among these were traced and negative aspects of the excessive development. The possibility of combined use of a microalgae for wastewater treatment and their subsequent using for food is a very perspective direction in which direction the studies should continue.

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